DIGEST

BIODIVERSITY AND ONSHORE WIND POWER

The impacts of onshore wind power on biodiversity and recommendations for assessing the risks

The International Renewable Energy Agency has set an optimistic plan to increase decarbonized electricity production from renewable sources from 25% in 2017 to 85% in 2050. Driven by technological advancements, economies of scale, competitive supply chains and developer expertise, the cost of renewable electricity has come down significantly over the last decade, contributing to socio-economic and human development. Although increasing wind power capacity is crucial for mitigating climate change, the potential effects on biodiversity require that adjustments be made so that biodiversity loss does not exacerbate climate change, or degrade food production or human health. Indeed, an estimated 11 million hectares of natural land on the planet could be lost because of wind and solar power, which would have an impact on more than 3.1 million hectares of key biodiversity areas and 1,500 threatened vertebrate species, especially in the tropics.

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Onshore Wind Power and Its Environmental Impacts: An Overview

The main impacts of wind energy occur during the construction and operational phases.

Habitat loss caused by the clearing of forested areas during the construction phase has negative effects on forest-dwelling animal species.

During the operational phase, the primary disturbances caused by wind turbines result from **rotor movement**, **noise**, **vibrations, flickering lights**, and **increased human presence**.

These disturbances lead to **mortality** or **behavioral changes** in many animal species, such as **avoidance behavior** and c**hanges in flight paths**, especially in migratory species.

Avoidance behavior can occur at various scales: across the entire wind farm, within it, or in close proximity to individual turbines.

TYPES OF IMPACTS ON BIODIVERSITY:

- Direct mortality from collisions,
- Indirect mortality due to reduced habitat quality and resource availability near wind turbines,
- Avoidance or displacement behaviors resulting from the loss of perching sites, food sources, habitat, or the creation of ecological barriers.

Consequences of land-use changes

For an equivalent amount of energy, renewable energy sources require significantly more land than fossil fuels or nuclear energy. As a result, the energy transition must navigate complex trade-offs between natural, agricultural, urban, and energy-related land uses.

Electricity generation from renewable resources also requires the construction of transmission corridors, roads, service buildings, and other extraction or transport infrastructure. While power lines and roads occupy relatively small surface areas, they can cause ecosystem fragmentation, which leads to significant cumulative effects on biodiversity, land use, and land rights.

In particular, in countries of the Global South, the positive incentives and perceptions surrounding renewable energy have led to large-scale, long-term land acquisitions by government agencies or private investors. These changes have triggered major shifts in land use patterns and land tenure systems. As a result, subsistence farmers, pastoralists, and Indigenous peoples are often denied access to pastures and water sources, compromising their livelihoods and cultural identity. These processes are also accompanied by biodiversity loss, due to landscape homogenization caused, for example, by the establishment of large wind farms.

WHAT DOES SCIENCE SAY?

Impacts of onshore wind energy on wildlife displacement:
Insights from the knowledge synthesis by Tolvanen *et al.* (2023)

The authors conducted a systematic review on the impact of wind turbines on birds, bats, and terrestrial mammals. This review included 84 studies published between 1993 and 2023, representing 160 distinct displacement distances.

The findings show that:

- 63% of birds, 72% of bats, and 67% of mammals altered their movements to avoid wind turbines.
- In 100% of the cases, cranes, owls, and semi-domesticated reindeer showed avoidance behavior.
- On average, birds moved 5 km away from wind turbines. However, in some cases, no displacement was recorded.
- In most studies, bats moved about 1 km.
- On average, waterbirds, raptors, passerines, and waders moved 500 meters.

These results suggest:

- A significant loss of functional habitat for these species.
- For flying species such as raptors and bats, displacement and collisions can contribute to population declines.
- For terrestrial mammals, relatively few studies have examined the distances of displacement so far.

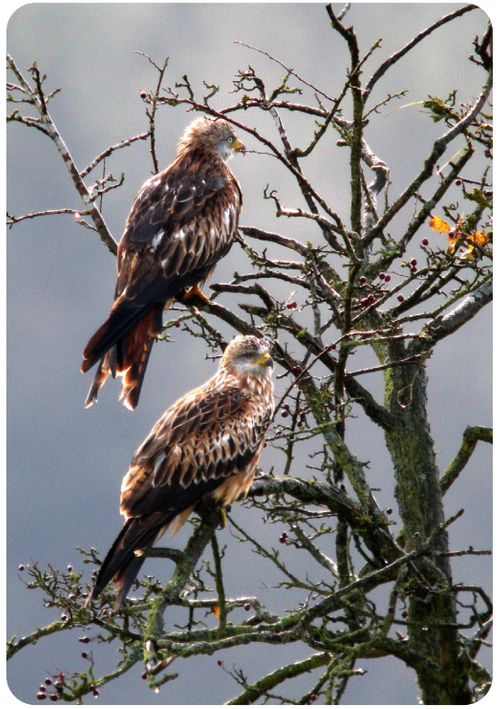
The displacement distances reported in this study can help mitigate the negative effects of onshore wind energy by:

- Avoiding areas of high importance for threatened species,
- Minimizing habitat loss and collisions at local scales,
- Restoring or creating high-quality habitats to compensate for functional habitat loss.

Improving our understanding of wildlife movement patterns remains essential to define the distance thresholds at which wind farm installations have limited impact on biodiversity, and to help reduce negative effects on sensitive species.

BIRDS

Birds are impacted by **direct collisions**, **changes to their habitat,** and **turbine noise and lights**. Species with the highest mortality are those whose **flight space corresponds to the turbines' swept area.** This affects species with large populations such as larks (*Eremophila alpestris*, *Alauda arvensis*, *Chersophilus duponti*), but also protected species, especially migratory birds and raptors. The disturbance caused by these installations also induces **avoidance behaviours** that are more or less pronounced depending on the species.



FOCUS ON RAPTORS

Faced with the development of onshore wind power, bird populations are particularly vulnerable, especially raptors with long lifespans and low reproductive rates such as lesser kestrels (*Falco naumanni*) and red kites (*Milvus milvus*). **Changes in the movements of these species influences their abundance during the breeding season, increases nest abandonment, and reduces reproductive success.** Combined with the effects of collisions, this can lead to a spiral of extinction of local populations.

KEY FIGURES

In 2018, studies in the United States estimated that **573,000 birds die each year due to wind turbines, of which 83,000 were raptors**.

CHAUVES-SOURIS

Bats are particularly vulnerable to **the risk of deadly collisions**. They appear to not be able to detect turbine blades, which have rotation speeds at their tip of up to 300 km/h. Moreover, during migration or while foraging, bats that fly in the rotor's swept area can be attracted to the turbines. This attraction varies depending on the species, the sex and age of the individuals, the time of year, and the location of the turbines.

This attractive effect may be due to the presence of a high number of prey insects near the turbines, which are themselves attracted to the turbines' colour and the heat it produces. Most carcasses of eastern red bats (Lasiurus borealis) and hoary bats (Lasiurus cinereus) found near wind farms had a full stomach.

These observations suggest that individuals were killed while foraging.

The attractiveness of wind turbines may also be due to the presence of mating partners and perching sites, especially for tree bats that perceive turbines as trees.

Bats can also die from **barotrauma**, **a sudden drop in air pressure in the vicinity of the moving blades.**

KEY FIGURES

In 2013, an American study estimated that **888,000 bats die each year in the United States due to wind turbines.**

WHAT DOES SCIENCE SAY?

- In France, a 2017 study by the Regional Directorate for Environment, Planning and Housing (DREAL) showed that noise from **construction activities could damage the hearing capacity of certain species that regularly hunt by passive listening**, such as the greater moused-ear bat (*Myotis myotis*) and long eared bats (*Plecotus*), thus affecting their search for food.
- Bats are also impacted by **the loss and degradation of their habitat**.
- Many studies have shown that **mortality by collision alone could threaten the viability of populations and lead to an increased risk of extinction.**
- Knowledge of the impacts can be used to avoid or reduce them:
  - Numerous studies on the effect of turbine size, density and average rotation speed on European bats suggest that **it is necessary to avoid high turbine densities and bigger rotors.**
  - Studies have highlighted the importance of installing wind turbines as far away as possible from favourable habitats such as forest edges, making sure not to place them between these habitats and the source of the prevailing winds.

OTHER MAMMALS

Because of **habitat fragmentation, a change in habitat quality**, and other disturbances caused by the development of wind power, **large mammals have changed their use of space and their migration patterns.**

Concernant les petits mammifères, leur capacité à se déplacer étant limité, ces derniers sont davantage sensibles à la perte et à la fragmentation de leur habitat.

FOCUS ON
SEMI-DOMESTICATED REINDEER

Many studies have focused on semi-domesticated reindeer in the mountainous regions of northern Scandinavia, a region with high potential for the development of wind power.

Potential grazing areas for these animals, which are known to travel long distances, are decreasing and are already degraded by forestry, mining, livestock, and climate change. Consequently, semi-domesticated reindeer are increasingly kept in enclosures and fed during the winter. It is likely that changes in reindeer management will allow reindeer to become better habituated to the presence of wind turbines than wild animals.

By contrast, the abundance of large predatory mammals may increase in areas of wind power development, since they take advantage of roads to travel.

INSECTS

Many insect species fly at heights of between 0 and 30m for their daily travels, which is below the swept area of the turbine blades. Thus, disturbance levels are low. Consequences are quite different during migration, when insects fly at higher altitudes (40 to 100m) to take advantage of the strong, non-turbulent directional winds to reduce their energy expenditure and optimize their flight paths. **Besides, it is for the same reasons of optimization and favourable wind conditions that wind farms nearly always cross the migration routes of birds and insects.**

FOCUS ON
A SOLUTION TO MITIGATE THE IMPACT ON FLYING INSECTS

Lidar is a technology that can detect airborne particles as they approach a wind farm, predict wind speed, and follow insect swarms at rotor height. It could trigger the stoppage of the rotor blades if insect densities at rotor height become critical, thus reducing the damage caused to insects. Multiple studies have shown that these types of measure would only have negligible impact on energy yield.

These impacts occur during migration, shortly before the annual breeding process. They therefore probably have a knock-on effect on subsequent generations and species survival. Despite evidence of this impact, and even though the global decline in insect biomass has been reported in numerous studies, wind power is seldom considered as a factor contributing to insect decline.

KEY FIGURES

Worldwide, wind power potentially induces the loss of **120,000 tons** of insect biomass, corresponding to **120,000 billion** individuals each year.

RECOMMANDATIONS

During project development

- Carry out more observations and research studies prior to the construction of a wind farm, or a group of wind farms, in a given area in order to precisely identify areas where wind turbines should not be built. This will help reduce the impact on migratory species whether during their flight or their nocturnal rest periods.
- Draw risk maps for different sensitive species to allow for a reasonable spatial planning of wind power development and to define exclusion zones.
- Quantify the loss of habitat use from the installation of individual wind turbines or wind farms and estimate its environmental consequences.
- Take into account the cumulative effects of the multiplication of the number of wind farms in a given area on species and trophic networks.

During construction

- Install wind power infrastructures in habitats with poor environmental quality, minimize habitat loss and small-scale collisions, and create high quality habitats to compensate for habitat loss.
- Encourage "before-after-control-impact" studies, which are mandatory for the approval of and for any decisions associated with the development of wind power projects.

During operation

- Investigate the consequences associated with avoidance behaviours, which are more difficult to establish than direct mortality by collision, especially for reptiles, amphibians, and invertebrates.
- Assess the quantitative importance and consequences of mortality by collision on population dynamics for individual species, by time period, or by eco-physiological state.
- Characterize the impact of the loss of hunting grounds and feeding habitats due to the presence of wind turbines on individuals and populations.
- Study the behavioural effects of noise and electromagnetic fields.
- Assess technological innovations or operational changes designed to avoid collisions.

From mitigating climate change to biodiversity loss: the issue of environmental problem shifting

It is important to analyze how the measures taken to mitigate climate change may impact other issues. The deployment of onshore wind power is effective for mitigating climate change. There is a clear benefit in this regard compared to the use of fossil fuels. However, the impact of wind power on biodiversity could be greater than that of its fossil-based alternatives, inducing knock-on effects through local perturbations of ecosystems and trophic levels. Indeed, these new impacts could induce a poorer regulation of air and water quality, a reduction in pest regulation, diminished pollination of food crops, and the emergence of epidemics. The shift in impacts will vary depending on the geographical context, for instance the prior uses of the land, the characteristics of the wind farm (e.g. turbine size), and the upstream source of energy. The IPBES Nexus report examined in detail the link between climate change and biodiversity loss, and suggested complementary measures to minimize a shift in impacts. Complementary policies, using economic, incentive, and regulatory approaches, can also minimize this shift.

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